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A SUMMARY OF STATISTICS
RELATING TO
VACCINATION AND SMALLPOX

*As observed in the Cases admitted to the City of Glasgow
Smallpox Hospital, Belvidere, between 10th April,
1900, and 30th June, 1901.*

BY

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ROYAL PHILOSOPHICAL SOCIETY OF GLASGOW.

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A Summary of Statistics relating to Vaccination and Smallpox as observed in the cases admitted to the City of Glasgow Smallpox Hospital, Belvidere, between 10th April, 1900, and 30th June, 1901.

By R. S. THOMSON, M.D., D.Sc., F.F.P.S.G., F.R.S.E., Professor of Medicine, Anderson's College Medical School; Visiting Physician to the City of Glasgow Smallpox Hospital, Belvidere, and

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[Read before the Society, 2nd April, 1902.]

DURING the past two years Glasgow has suffered from one of the most severe epidemics of smallpox which has visited the city within recent times. The disease is still in our midst, and at present there are in the Smallpox Hospital close upon 200 patients. The epidemic began in April, 1900, and tailed off, as is so commonly the case with smallpox, on the advent of warmer weather, towards the middle of June of last year.

The purpose of this paper is to bring under the notice of the members of this Society what has been learned of the influence exercised upon smallpox by vaccination, by a study of the cases admitted from the beginning of the epidemic till its temporary cessation in June.

Before proceeding to consider the different points in detail, it will render the subject more clear if we discuss briefly the various terms used in the description of vaccinal scars, or what are more popularly known as "vaccination marks," as well as in the description of the smallpox eruption.

In every case admitted to the wards a note is made of the following points, namely, whether the patient is vaccinated, and if so, what is the number of recognisable vaccinal scars, and at the same time a careful description is written down of the characters presented by these. The characters of the vaccinal scars are of the first consequence in estimating the probable protective value of the vaccination, for, though vaccination with pure lymph produces

a very characteristic scar, this may be much modified by secondary infection of the vesicle or pustule by pus-producing organisms during the acute stages of the process, and by age.

Vaccination performed with uncontaminated lymph, and which has not been complicated by secondary infection, results in a scar well defined at the margin, slightly depressed below the surface, and covered with minute pits or "foveae." Such a scar possesses the best possible characters, and indicates a vaccination of the most successful kind. When secondary infection of the vesicle or pustule by pus-forming organisms takes place, the point of inoculation becomes the seat of a process of ulceration, or even sloughing, and under these circumstances the vaccinal scar loses its characters, either in part or altogether, and instead of a scar such as has been described, we have one which presents little or no trace of foveation, which is glazed, irregular, and often puckered, resembling that produced by a burn of limited extent, but penetrating deeply through the true skin. In elderly persons even well foveated scars gradually become smoothed out, losing their foveation to some extent, and becoming ill-defined at the edges. Scars following on the healing of vesicles or pustules the seat of secondary infection are often very large, but it must be obvious that as the destructive process which produces them is dependent not upon the virus of vaccinia, but upon the presence of pus-forming organisms, it is impossible to gauge the protective influence indicated by such scars. Yet, judging from the experience gained in the Smallpox Hospital, it would seem as if the pyogenic organisms exercise some deleterious or inhibitory influence upon the vaccine virus, so that the degree of protection is not so great as the size of the scar might suggest.

The *scar area* or extent of surface covered by the "vaccination mark," is carefully measured, the area being expressed in tenths of a square inch. In the case of scars which are partly foveated or pitted, and partly free from foveation, the extent of the foveated area is also noted. In classifying scars as "foveated" and "non-foveated," it is customary in the Smallpox Hospital to regard as foveated all scars in which one half or more of the area is covered with foveae, while any scar which presents foveae over less than one half its area is regarded as non-foveated.

The condition of the patients as to vaccination leads to their distribution into three groups—"Vaccinated," "Unvaccinated," and "Doubtful."

All patients who show unequivocal evidence of "primary" vaccination, that is, who have been vaccinated once, either in infancy or in later life, and present one or more scars in evidence of this primary vaccination, are classed together as "Vaccinated," and all scars, however minute, and however far they may depart from the ideal standard, are accepted as evidence of vaccination. Persons who present no evidence of primary vaccination, and who state frankly that they have never been vaccinated, are classed as "Unvaccinated." Those who come much into contact with smallpox, are aware that among the patients, individuals are occasionally found who can give no information as to whether or not they have been vaccinated. If such individuals shew evidence of vaccination by the presence of vaccinal scars, they are regarded as having been vaccinated, but if there is no such evidence they are classed as "Doubtfully" vaccinated. Absolute want of knowledge with regard to vaccination is, however, rarely found. In addition to those cases in which no information is forthcoming, it is not very uncommon to meet with persons who declare they were vaccinated in infancy, but who present no local evidence in the shape of vaccination scars. In these also the vaccination is regarded as doubtful. Finally, in a small proportion of confluent cases, where the patient has come under observation late in the disease, it is impossible to discover any trace of vaccinal scars. In these the vaccination is regarded as doubtful unless the patient is clear that he is an unvaccinated subject. It would obviously be unjust to classify such persons as either vaccinated or unvaccinated, and consequently these constitute a third group of doubtful cases.

Though classed for statistical purposes among the Vaccinated, yet "Revaccinated" persons may fairly be regarded as forming a fourth group. As revaccinated are classed those in whom there is a clear history of a second vaccination having been performed at some period subsequent to the primary operation. It will be proper to state here that many persons in whom revaccination has been attempted, but in whom no reaction followed upon the operation, consider themselves revaccinated; yet it must be obvious that revaccination can be regarded as having been performed only when the person has presented a distinct local and constitutional reaction. The evidence of revaccination is often purely historical, on account of the rapidity with which in some cases the scars become effaced

even when the revaccination has resulted in a decided local reaction.

During an epidemic all "Contacts" who will submit to the operation are vaccinated or revaccinated as the case may be. If the operation has been performed during any part of the "incubation period," that is to say, during the period which elapses between exposure to infection and the first appearance of symptoms, a period which varies from eight to seventeen days, but is most commonly eleven or twelve, the operation is not regarded as a revaccination in the ordinary sense. A true revaccination must be performed *before* exposure to infection.

In studying the relationship existing between vaccination and smallpox it is important that the members of this Society should have some knowledge of the disease with which we are dealing, especially with regard to its various grades of severity. When smallpox for the first time attacks a person who has never been vaccinated, the disease is said to run an "unmodified" course. In vaccinated persons, however, so long as the vaccination continues to confer some degree of immunity, the disease does not follow the usual course, and the attack is said to be "modified." It is a mistake to suppose that all unmodified attacks are necessarily severe, for individuals manifest very various degrees of susceptibility to the contagion. Some persons who have never been vaccinated apparently enjoy complete immunity against the disease, and in the Smallpox Hospital at least two such persons have come under observation during the last ten years, both living in the wards among the Smallpox patients apparently in perfect security: neither of these was susceptible to vaccination. All grades of susceptibility are found in unvaccinated persons between this apparent immunity and the highest grade of susceptibility, such as is probably present in those who are attacked by the disease in its virulent forms.

In both modified and unmodified smallpox the *amount* of the eruption is commonly regarded as indicating the severity of the attack, but it should be pointed out that this is not an invariable guide, as in modified cases a most profuse eruption not unfrequently "aborts," or in other words, the rash does not pass through all its stages of development, as it invariably does in the unmodified disease, the attack ending late in the vesicular or early in the pustular stage. In persons suffering from a second attack of smallpox the eruption runs a similarly modified course.

With this reservation, it is found convenient for purposes of classification to divide all cases of smallpox into groups according to the abundance of the eruption on the patient's face. When the eruption appears on the face in the form of isolated pocks the case is regarded as a "discrete" one, but it must be remembered that in this class are included not only the milder cases with perhaps not more than half-a-dozen pocks in all, but also a fair number of considerable severity, in which there may be many hundreds of pocks scattered over the surface of the body. When the pocks are so abundant on the face and possibly on other parts that they come into contact by their edges, the case is regarded as "confluent," and the patient, if unvaccinated, is the subject of an attack of great severity.

In addition to these classes there is a third group of cases in which the eruption is usually very abundant if the patient survive for eight or ten days, and in which in addition to the true and characteristic eruption of smallpox, there are present in the skin and mucous membranes hæmorrhages varying in size and in number. In many of these patients hæmorrhage takes place from the nose, lungs, stomach, bowel, kidneys, etc. If death occur early in the attack, the characteristic eruption of pocks may be almost absent. Such cases constitute the "malignant" or "hæmorrhagic" group. It must be understood that the grades of severity indicated by this classification are "discrete" or comparatively mild, "confluent" or very severe, and lastly the true "hæmorrhagic" condition, in which recovery rarely takes place. As already stated, however, many of the cases classed as confluent are by no means so severe as would be suggested by the amount of the eruption, for it is only in unvaccinated persons and in those who have completely lost the immunity originally conferred by primary vaccination, that the eruption follows its normal course of development, while in those who still enjoy a certain degree of immunity, the eruption, though abundant, runs a comparatively short-lived course.

Bearing these facts clearly in mind we are now in a position to enquire what influence vaccination was found to exercise on the course and termination of smallpox as seen in the wards of the Hospital. During the period under consideration 1,810 persons were admitted to the wards suffering from this disease. Of these, 1,643 were vaccinated, in 45 the vaccination was doubtful, while 122 were avowedly unvaccinated.

The influence of vaccination upon smallpox may be studied along various lines, but perhaps the most striking results are obtained when we compare the case mortality among the vaccinated, doubtfully vaccinated, and unvaccinated. Of 1,643 vaccinated persons 150, or 9·13 per cent. died; of 45 doubtfully vaccinated persons 25, or 55·55 per cent. died; while among 122 unvaccinated persons there were 63 deaths, giving a case mortality of 51·64 per cent. In all of the 1,810 patients admitted, 238, or 13·15 per cent. died. These figures can be more readily compared in the accompanying table.

TABLE SHOWING RELATIVE CASE MORTALITY IN VACCINATED, DOUBTFUL, AND UNVACCINATED CASES.

Condition as to Vaccination.	Number of Cases.	Deaths.	Per Cent.
Vaccinated, - - -	1,643	150	9·13
Doubtful, - - -	45	25	55·55
Unvaccinated, - -	122	63	51·64
	1,810	238	13·15

From this it will be seen that the mortality among vaccinated persons is less than one-fifth of the mortality among unvaccinated, and curiously enough only about one-sixth of that occurring among persons doubtfully vaccinated. This latter result does not correspond with what was observed in the epidemic of ten years ago, in which the case mortality among the doubtfully vaccinated was little more than one-half of that among the unvaccinated.

The higher case mortality observed in the present epidemic among the doubtfully vaccinated as compared with the unvaccinated is probably in part the result of the smaller number of the former coming under observation; but it must be remembered that though, as will be shewn in a subsequent part of this paper, some of those classed as doubtful were probably vaccinated in infancy, yet in them the operation was so inefficiently carried out that it conferred an immunity of a very temporary character only, and consequently such persons, when brought into contact with the smallpox contagion, were really in the position of those who had never been vaccinated. Examples of this shortlived immunity are not infrequently seen in the smallpox Hospital, where children suffering from diseases other than smallpox, and with imperfect vaccination scars, if revaccinated within one or two years after the primary operation, pass through a typical attack of vaccinal fever, with a characteristic local reaction which runs the

usual course. The vaccinator or the lymph employed is not always responsible for the partial or total failure of the operation, for attempts more or less successful are quite commonly made by parents or guardians who disapprove of vaccination to render the operation useless, by washing or sucking the part to remove the lymph before it becomes dry.

In connection with the question of doubtful vaccinations it has been suggested that a reference to the books of the Registrar might clear up the doubt, but though this source of information might sometimes prove useful, it would not infrequently afford no assistance of any value, as the experience of the hospital shews that children are sometimes registered as successfully vaccinated who present, even a few weeks after the alleged operation, no discoverable trace of a vaccinal scar.

It might be urged that all the doubtful cases should be regarded as vaccinated, though, in view of what has been said on the point, this would be manifestly unjust. Yet, for the sake of contrast, we may for a moment regard the doubtfully vaccinated as belonging to the vaccinated class of persons, and what result do we get? Among a total of 1,688 persons suffering from smallpox we have 175 deaths, or a case-mortality of 10·41 per cent., that is, the case-mortality is raised by only 1·28 per cent. It would be equally unjust to regard these doubtful cases as unvaccinated, but if we include them in the unvaccinated class, we have a total of 167 cases with 88 deaths, giving a case mortality of 52·7 per cent., or 1 per cent. greater than that of the unvaccinated class.

Leaving the doubtful cases out of consideration, and confining our attention to the vaccinated and unvaccinated, as given in the above table, we are driven to the conclusion that, whatever direct or indirect influence vaccination may have upon the result, vaccinated persons run a much smaller risk of death in the event of their contracting smallpox than do those who are unvaccinated.

It may be asked why the case mortality among unvaccinated persons is greater at present than it is said by some to have been in pre-vaccination times. In reply, it may be pointed out, in the first place, that there are no really reliable statistics dealing with large masses of cases; and in the second, that the available statistics are vitiated by their including persons suffering from inoculated smallpox, a form of the disease which was notoriously mild. Apart from statistics, however, a fair idea may

be gathered from the works of the older writers of the dreadful mortality which prevailed in their time among the victims of smallpox, compared with which the present mortality among unvaccinated persons does not seem to be unduly great.

Almost as striking as the relative case-mortality is the comparative severity of the attack, as studied in vaccinated, doubtfully vaccinated, and unvaccinated persons. Among 1,643 vaccinated persons there were 1,361 or 82·8 per cent. of discrete, or, in other words, comparatively mild cases ; 237 or 14·4 per cent. of a more severe type, in which the eruption was confluent ; and 45 persons or 2·8 per cent. suffered from malignant smallpox.

Of 45 doubtfully vaccinated persons 15 or 33·3 per cent. passed through an attack associated with a discrete eruption, while in 25 or 55·6 per cent. the eruption was confluent, and hæmorrhagic in 5 or 11·1 per cent.

One hundred and twenty-two unvaccinated persons came under observation, of whom only 53 or 43·3 per cent. were discrete, 65 or 53·3 per cent. were confluent, and 4 or 3·3 per cent. hæmorrhagic. This contrast is brought out in the accompanying table—

TABLE SHOWING SEVERITY OF ATTACK IN VACCINATED, DOUBTFUL,
AND UNVACCINATED CASES.

Condition as to Vaccination.	Discrete	Confluent.	Hæmorrhagic.
Vaccinated, - 1,361.	82·8 per cent.	237. 14·4 per cent.	45. 2·8 per cent.
Doubtful, - 15.	33·3 „	25. 55·6 „	5. 11·1 „
Unvaccinated, - 53.	43·4 „	65. 53·3 „	4. 3·3 „

which shows, with great clearness, that a vaccinated person contracting smallpox, has the advantage over one who is either unvaccinated or doubtfully vaccinated ; so that, whatever view may be taken as to the causative influence exercised by vaccination, persons successfully vaccinated not only run less risk of death when attacked by smallpox, but also as a rule pass through a milder attack than do their less fortunate unvaccinated fellows ; and, though this fact is not brought out in either of the tables we have discussed, yet it is a fact that disfigurement, such as pitting, deafness, and blindness, and permanent injury to health are most exceptional among the vaccinated.

Not only do vaccinated persons suffer less themselves, but they are likewise the cause of less suffering to their families, and a source of less expense to the community. An attempt is

made to show this in the following table, which deals with the duration of the patients' stay in hospital, in those cases where the illness terminated favourably.

TABLE SHOWING AVERAGE DURATION OF STAY IN HOSPITAL IN
VACCINATED, DOUBTFUL, AND UNVACCINATED CASES.

Vaccinated cases detained an average of 29 days.

Doubtful	„	„	41	„
Unvaccinated	„	„	56	„

It will be seen that the average residence of vaccinated was practically one-half that of unvaccinated persons, or in other words those who had been even once vaccinated were able to return to their families, and, so far as their health was concerned, resume their ordinary occupations twenty-seven days sooner than their unvaccinated companions. As most of the patients belong to the working-class, the early return of the bread-winner to his home is a matter of importance for those he is called upon to support. But the influence of his earlier dismissal from hospital goes further than this, extending immediately to his employers and fellow-workmen, whose business is often hampered by his absence; and even the community at large is affected favourably by the vaccinated as contrasted with the unvaccinated patient, for, taking the average expenditure for each patient in hospital at 4s. 6d. per day, we find that while each vaccinated person costs the ratepayers £6. 10s. 6d. during his detention in hospital, the unvaccinated costs £12. 12s. or nearly double that sum.

Turning now to the vaccinated cases, an attempt will be made to discover whether the number, size, and characters of the vaccinal scars constitute any index of the degree of protection—afforded by primary vaccination.

The *number* of the vaccinal scars will be discussed first.

TABLE SHOWING RELATION BETWEEN NUMBER OF SCARS AND
SEVERITY OF ATTACK.

Number of Scars.	Discrete.	Confluent and Hæmorrhagic.	Deaths.	Total Cases.
One scar, - -	709	177	101	886
Two scars, - -	506	83	43	589
Three scars, - -	81	13	4	94
Four scars and over,	65	9	2	74

TABLE SHOWING THE SAME FIGURES REDUCED TO PERCENTAGES
OF THE TOTAL CASES IN EACH CLASS.

Number of Scars.	Discrete.	Confluent and Hæmorrhagic.	Deaths.
One scar, - - - - -	80	20	11·4
Two scars, - - - - -	85·9	14·1	7·3
Three scars, - - - - -	86·2	13·8	4·2
Four scars and over, - - - - -	87·8	12·2	2·8

From this table it will be seen that out of a total of 1,643 small-pox patients, 886 presented one scar, 589 two, 94 three, and 74 four scars and upwards; and in addition that the degree of protection was in direct proportion to the number of scars. The percentages showing the number of discrete or mild cases, while they indicate an increase in the degree of protection with an increase in the number of scars, do not show any striking difference between each of the four groups. This slight difference is precisely what is to be anticipated when we remember that the great majority of vaccinated persons who contract smallpox suffer from a discrete or modified attack, whatever the number of vaccinal scars. The difference, however, is more striking when we consider the case-mortality in the various groups. A glance at the table will show that while persons presenting only one scar had a case-mortality of 11·4 per cent., those who presented four scars or upwards had a case-mortality of only 2·8 per cent., a fact which, so far as it goes, is in favour of vaccination being performed at more than one point. From this the question arises whether the comparative immunity enjoyed by persons with four vaccinal scars, as compared with those possessing fewer, is to be estimated by the number of scars present, or whether the greater degree of protection is associated with the greater *scar area*. Most persons who have been vaccinated at more than one point present as a rule vaccinal scars which differ from one another in form and character, but more especially in size, and the question to be decided is whether the size of the area covered by vaccinal scarring is in any way proportionate to the degree of immunity enjoyed. In the accompanying table an attempt is made to throw light upon this point.

TABLE SHOWING RELATION BETWEEN AREA OF SCARS AND
SEVERITY OF ATTACK.

Area of Scars in sq. in.	Discrete.	Confluent and Hæmorrhagic.	Deaths.	Total Cases.
Under ·25 - - -	187	71	50	258
·25—5 - - -	369	98	61	467
·5—1 - - -	520	79	34	599
1 and over - - -	285	34	5	319

TABLE SHOWING THE SAME FIGURES REDUCED TO PERCENTAGES
OF THE TOTAL CASES IN EACH CLASS.

Area of Scars in sq. in.	Discrete.	Confluent and Hæmorrhagic.	Deaths.
Under .25 - - - - -	72.5	27.5	19.4
.25—.5 - - - - -	79	21	13
.5—1 - - - - -	86.8	13.2	5.7
1 and over - - - - -	89.3	10.7	1.6

Formerly, vaccinal scars were classed as “very good,” “good,” “indifferent,” “bad,” and “very bad,” and the older statistics dealing with vaccination employ this or a similar classification, which embodies not only the size of the vaccinal scars, but their characters as well. The objection to this classification is obviously that it leaves too much to be determined by the personal equation of the observer, and consequently it became necessary in the preparation of detailed statistics to employ accurate methods of measurement. A number of years ago the Metropolitan Asylums’ Board introduced a method which admits of the ready comparison of scars presenting different forms and sizes. According to this method each scar is carefully measured, and the total combined vaccinal scar area is expressed in inches and tenths of an inch. In the above table the cases are divided according as their total scar area measured less than a quarter of a square inch, from quarter to half a square inch, from half to one square inch, and one square inch or over. The severity of attack is indicated by the terms discrete or confluent and hæmorrhagic. A glance at the table will show that the percentage of discrete cases is directly as the scar area, there being about 17 per cent. more discrete cases where the scar area measured over one inch, than where it measured less than a quarter of a square inch. A similar comparative immunity will be noticed if we glance at the percentages of the severer cases, for while persons possessing a scar area of less than one quarter of a square inch presented 27.5 per cent., those with a scar area of over one square inch presented only 10 per cent. of the more severe forms of the disease. The case mortality is even more striking, for while there were 19.4 per cent. of deaths among persons with a scar area measuring less than one quarter of a square inch, among persons with a scar area over one square inch the case-mortality was only 1.6 per cent.

The limits of this paper prevent a detailed discussion of the scar characters, which would involve a degree of technicality to be

fully appreciated only by those familiar with vaccination and its results. But it may be of interest to discuss shortly at least one characteristic of all satisfactory vaccinal scars, namely, *foveation*. In the appended table the cases are divided according as the scars did or did not possess this character.

TABLE SHOWING INFLUENCE OF VACCINATION ON SEVERITY OF ATTACK AND CASE-MORTALITY WHEN SCARS ARE "FOVEATED" AND "UNFOVEATED."

					Discrete.	Confluent.	Hæmorrhagic.	Deaths.
Character of attack in 655 Persons								
with Foveated Scars, -					573	75	7	43
Per Cent., - - - -					87·5	11·5	1	6·6
Character of attack in 988 Persons								
with Unfoveated Scars, -					788	162	38	107
Per Cent., - - - -					79·8	16·4	3·8	10·8

A definition of what is meant by foveation and non-foveation has been given in a former part of this paper. It will be seen from the table that of 1,643 vaccinated persons, 655 possessed foveated scars, and 988 scars which were regarded as unfoveated. The statistics here given are distinctly favourable to those with foveated scars, for while among these there were 87·5 per cent. of milder cases, there were 79·8 per cent. among those whose scars were unfoveated. Among the more severe cases a similar comparative immunity is seen, for while there were only 11·5 per cent. of confluent cases, and only 1 per cent. of hæmorrhagic in those with foveated scars, there were 16·4 per cent. of confluent, and 3·8 per cent. of hæmorrhagic cases among those whose scars were not foveated. The case-mortality in the two classes points in the same direction, for while there were 6·6 per cent. of deaths among the foveated, the unfoveated showed a mortality of 10·8 per cent.

Turning now to another part of our subject, the *age-incidence* of the disease falls to claim our attention. This will be discussed first, as it appears among persons who have been vaccinated in infancy or in later life, secondly, in those who avowedly have never been vaccinated, and lastly, as it appears in those persons in whom vaccination is doubtful.

Our first table deals with vaccinated persons only.

TABLE SHOWING SEVERITY OF ATTACK AND CASE-MORTALITY IN
 VACCINATED CASES AT DIFFERENT AGE PERIODS.

Age.	Discrete.	Confluent.	Hæmorrhagic.	Total.	Deaths.	Mortality. per Cent.	Percentages of Severe Cases.
0-5	3	—	—	3	1	33·3	—
5-10	30	1	—	31	—	—	3·2
10-15	89	4	—	93	1	1·1	4·3
15-20	122	9	—	131	—	—	6·9
20-25	225	24	5	254	12	4·7	11·4
25-35	525	87	15	627	42	6·7	16·3
35-45	253	75	14	342	51	14·9	26
45-55	82	29	6	117	26	22·2	30
55-65	19	7	5	31	13	41·9	39
65 and over	13	1	—	14	4	28·6	7·1
	1361	237	45	1643	150		

The cases are grouped in quinquennial age periods up to the age of twenty-five years, and in decennial periods beyond that age. A glance at its column reveals a most interesting fact, and one which has been commented upon from the earliest period of general vaccination, namely that out of 1,643 cases of smallpox occurring in vaccinated persons, only 258—or 15·7 per cent. of the whole—were under twenty years of age, and further, that of this number only two or about 0·8 per cent. died. The absence of severe cases during the same age-period is also strikingly shown, as only 14 or 5·4 per cent. of the cases were confluent, and none were hæmorrhagic. Over the age of twenty we find that the state of matters changes, both as regards the number of persons contracting the disease, and the percentage of severe cases and of deaths. It will be noted that from the age of twenty onwards, and including the age-period from 55 to 65 years, there is a steady increase both in the percentage of severe cases, and in the case mortality, while in the last age-period there is a decided fall in both.

The figures indicate the existence of a distinct relative immunity under the age of twenty, which it seems reasonable to attribute to the primary vaccination, and also that this immunity is gradually lost as the years advance, disappearing completely at various ages, the period of its disappearance seemingly depending upon the efficiency of the vaccination. When this protection is completely lost the patient reverts to the condition of one who has never been vaccinated, so that the course and result of his attack show no modification.

The fall in the case-mortality, and in the number of severe cases over the age of sixty-five, would suggest that over a certain age a natural relative immunity becomes developed.

Our next table deals with unvaccinated cases only.

TABLE SHEWING SEVERITY OF ATTACK AND CASE MORTALITY IN UNVACCINATED CASES AT DIFFERENT AGE PERIODS.

	Discrete.	Confluent.	Hæmorrhagic.	Total.	Deaths.	Mortality per Cent.	Percentage of Severe Cases.
0-5	29	25	—	54	36	66·6	46·3
5-10	5	7	—	12	2	16·6	58·3
10-15	5	8	1	14	4	28·6	64·3
15-20	3	3	—	6	2	33·3	50
20-25	1	5	—	6	4	66·6	83·3
25-35	3	7	1	11	5	45·5	72·7
35-45	4	6	2	12	4	33·3	66·6
45-55	3	4	—	7	6	85·7	57·1
55-65	—	—	—	—	—	—	—
65 and over	—	—	—	—	—	—	—
	53	65	4	122	63		

On contrasting the figures in this with those in the last table, we find a complete reversal of what is seen in vaccinated individuals. Out of a total of 122 unvaccinated cases no fewer than 86 or 78·5 per cent. occurred under the age of 20 years, while 54 or 44·3 per cent. of these occurred during the first quinquennial age period. This forms a striking contrast to what we saw existing among vaccinated persons, of whom only 15·7 per cent. were under 20 years of age, and only 3 or 0·2 per cent. were under the age of five. The conditions here demonstrated are precisely those which existed in prevaccination days, when smallpox, like measles, scarlet fever, and whooping cough, was strictly speaking a disease of childhood, the disease being less prevalent among adults, as measles is at the present day, probably because in communities between which free intercourse existed smallpox attacked every susceptible individual exposed to the infection, during the earliest years of life.

It is not the object of this paper to bring forward arguments or special pleading, its object is to set forth facts, and whatever explanation is offered, the bare fact remains that a disease which before the introduction of vaccination was notoriously a disease of early life, has so altered its age-incidence that in a community such as our own it has practically vanished from among vaccinated children under 5 years of age. It has been

pointed out in another part of this paper that the case mortality among the unvaccinated patients was 51·64 per cent. An analysis of our table gives further information on this point. Of the 86 patients under 20 years of age, 44 or 51·2 per cent. died, and all of these were cases of the severest type ; or to put it another way, of the 63 deaths which occurred among the unvaccinated patients, 44 or 71·4 per cent. were under the age of 20. Further, if we select the first quinquennial age period among the vaccinated, and contrast it with the corresponding period among the unvaccinated, we find that while in the former of three patients one died, in the latter of 54 patients 36 or 66·6 per cent. died.

Our next table deals with the age-incidence among persons in whom vaccination had been doubtfully performed. It is impossible of course to say what proportion of these were vaccinated and in what proportion vaccination had not been performed at all, but the mere classification of such cases as doubtful is sufficient to shew that if vaccination had ever been performed the operation must have been so inefficiently carried out that the local manifestations had in most part completely disappeared, probably long before the patient came under observation.

TABLE SHEWING SEVERITY OF ATTACK AND CASE-MORTALITY IN DOUBTFUL CASES AT DIFFERENT AGE PERIODS.

	Discrete.	Confluent.	Hæmorrhagic.	Total.	Deaths.	Mortality per Cent.	Percentage of Severe Cases.
0-5	2	1	—	3	—	—	50
5-10	2	—	—	2	—	—	—
10-15	2	—	—	2	1	—	50
15-20	1	1	—	2	1	50	50
20-25	—	2	1	3	2	66·6	100
25-35	3	8	1	12	9	75	75
35-45	2	8	1	11	6	54·5	81·8
45-55	2	3	2	7	4	57·2	71·4
55-65	—	2	—	2	1	50	100
65 and over	1	—	—	1	1	100	—
	15	25	5	45	25	55·55	66·6

This table does not suggest anything particularly striking, but attention may be called to one or two points. Of the 45 cases observed, 9 were under the age of 20, and 36 over that age. Of the cases under the age of 20, two died and two were severe, while over this age there were 23 deaths, more of these occurring between the ages of 25 and 35 than at any other age period.

The small number of cases under the age of 20 is comparable to what we saw in the table dealing with vaccinated persons, and suggests that many of the so-called doubtfully vaccinated had really been vaccinated at one time. The same is suggested by what we observe above the age of 20. The heaviest case-mortality among vaccinated persons was found between the ages of 55 and 65, as contrasted with the doubtfully vaccinated, among whom as already seen the greatest case-mortality occurred between the ages of 25 and 35 years. So that those persons classed as doubtful, though in many cases vaccinated in infancy yet were only temporarily protected by an operation so inefficiently performed that both the local scarring and the associated immunity disappeared at a comparatively early date thereafter. The temporary character of the protection indicated by the presence of scars of small size has already been referred to.

So far we have discussed the influence of *primary* vaccination only upon the course of termination of smallpox, and now it falls naturally to ask whether *revaccination* exercises any influence upon smallpox, either in protecting the person completely, or in modifying the attack should the disease be contracted. Just as the extent of protection afforded by primary vaccination bears some relation to the size and character of the resulting scars, or, in other words, to the efficiency of the operation, so, no doubt, the degree of protection afforded by revaccination will likewise depend upon the efficiency of the operation. Uniformity of result can be looked for only when there is uniformity in the operation itself, that is to say, when the operation is carried out on one general plan ; for, so long as one vaccinator considers that a scar, say the size of a shilling, is necessary to afford protection, and another that an area the size of a split pea will suffice, we cannot expect to find uniformity either in the degree or permanence of resulting immunity. Whether revaccination is the causative influence or not, it is undoubted that revaccinated persons rarely suffer from smallpox, and so far as the evidence of the present epidemic shews, recently revaccinated persons do not contract the disease at all. But here it is important to correct a common misapprehension as to what is meant by "revaccination." It is quite common, during the currency of an epidemic to be told that certain individuals have contracted smallpox within a variable but short period after revaccination. Careful enquiry invariably

shews that this statement is without foundation, and that the attempted revaccination had proved unsuccessful. Revaccination is not constituted by a few scratches made on the arm with a lancet or needle, and the rubbing in of a small quantity of vaccine lymph; to be successfully revaccinated the person must show both a local and general reaction, or, in other words, he must become the subject of an attack of vaccinal fever. If this double reaction does not take place, then either the individual is insusceptible, or the lymph and method of operating are defective. Again, it is common to find persons developing symptoms of smallpox a few days after successful revaccination; that is to say, the operation has been carried out during the period of incubation which, as already pointed out, extends on an average over eleven or twelve days. These persons are not revaccinated in the ordinary sense, in so far that the disease has been already contracted before the performance of the operation, though its symptoms do not appear till later. We shall see later on that revaccination, performed in the earliest days of the incubation period, seems to afford considerable protection against the disease.

We shall first consider the influence of recent revaccination when carried out efficiently. In the following table will be found details of revaccinated persons who were exposed, during longer or shorter periods, to smallpox infection within the area of the Smallpox Hospital, and in whom revaccination was performed by the medical officers of the smallpox staff, whose reputation for efficient revaccination cannot be questioned.

NUMBERS OF STAFF, WORKMEN, AND OTHERS EXPOSED TO INFECTION
WITHIN THE HOSPITAL PRECINCTS, SHOWING PROTECTIVE
INFLUENCE OF REVACCINATION.

	Total Numbers.	Revaccinated or recently Vaccinated for first time.	Not Revac- cinated.	Contracted Smallpox.	Deaths.
Medical and Nursing Staff, -	80	80	—	—	—
Practitioners and Students, -	150	150	—	—	—
Hospital Servants, - - -	50	50	—	—	—
Workmen, - - - - -	230	217	13	5	1
Vanmen calling at Hospital,	7	6	1	1	—
Patients suffering from Dis- eases other than Smallpox;					
Nursing Mothers, etc., -	236	236	—	2 ¹	—
	753	739	14	8	1

¹ These two cases were revaccinated with lymph which proved to be deficient in potency. This same lymph was found to be defective by others engaged in revaccination outside the Hospital.

Within the wards of the Hospital were employed 80 persons, constituting the medical and nursing staff, and 50 wardmaids and other attendants, all of whom were brought into most intimate contact with the ward inmates, and were consequently exposed to the infection in its most concentrated form. In addition to these, 236 persons, who were not suffering from smallpox, were brought in the wards of the Hospital into even closer relationship with the infection, in so far that these persons actually lived both day and night in the wards, occupying beds side by side with those in which smallpox patients lay. This number was made up of persons admitted with diseases other than smallpox; of persons without any discoverable disease; of mother's nursing their smallpox infants, and of healthy infants who were being suckled by their mothers who themselves were suffering from smallpox. It has been the custom in the Smallpox Hospital to revaccinate such persons immediately on admission, and thereafter daily till signs of local reaction appear, or the physician is satisfied that the patient is insusceptible to vaccinia, and presumably to smallpox also. In most of these cases *revaccination* is performed, but in the case of children at the breast the operation is commonly a *primary* one. These persons, as has been said, live among smallpox patients without any attempt at isolation, and many of them assist in the work of the wards. Mothers suffering from smallpox, if they are not too ill, are allowed to suckle their healthy children who, of course, are thoroughly vaccinated. Yet, in spite of the intimate contact between these recently revaccinated persons and the smallpox patients, it is excessively rare to find any of them contracting the disease; and when such an accident does happen, a careful search is certain to reveal some defect, most commonly in the lymph. During the period under consideration, of the 236 persons just mentioned only two contracted smallpox, and in both the disease was of so mild a type that the attack might quite readily have escaped notice. The explanation here seemed to lie in the fact that the vaccine lymph employed was deficient in potency, and the reaction, in spite of repeated daily vaccination, was so long delayed that these patients were in the same position as persons in whom the operation had been performed for the first time some days after exposure to the infection. Complaints of the quality of this particular batch of lymph were made both by physicians and

inspectors who were engaged in the work of revaccination outside the Hospital.

The numbers of those brought into intimate contact with the contagion of smallpox within the wards might be greatly increased, for at the acme of the epidemic the accommodation provided by the Smallpox Hospital was found to be insufficient, and sixteen wards of the Fever Hospital at Belvidere were for several months used for the overflow cases. In this way, practically the whole staff of the Fever Hospital, numbering 230 persons, all of whom had been revaccinated some time previously, was brought into the same relationship with the disease as the staff of the Smallpox Hospital itself; yet no member of the Fever staff contracted the disease.

During the prevalence of smallpox in the city, clinical demonstrations of the cases are given at intervals for the instruction of those practitioners and students who care to take advantage of them. To these demonstrations no one is admitted who has not been successfully revaccinated within three years, or has proved himself insusceptible after repeated attempts at revaccination. During the epidemic of last year 150 persons attended these demonstrations, and not one contracted smallpox.

It is well known that smallpox is one of the most infectious of the specific fevers, and that to contract it, it is not necessary that the susceptible individual should come into direct contact with a person suffering from the disease, or with infected articles, for there is reason to believe that the contagion may be conveyed even considerable distances through the air. It will be clear, therefore, that the whole precincts of the Smallpox Hospital must be considered an infected area, and any susceptible person entering this area will run a very serious risk of contracting the disease. It is further known that a susceptible person may contract the disease as the result of a very short exposure to the infection. This last fact is illustrated by the following incident. The Hospital supplies are brought from the outside, and there is a standing rule that all vanmen employed in this service must have been successfully revaccinated. Six regular vanmen, all of whom had been revaccinated, were employed, and none of these took smallpox, but on one occasion a substitute, who had not been revaccinated, was sent in place of one of these. This man paid only one visit to the Hospital, and was admitted a fortnight later with smallpox.

In this connection an experience falls to be related which presents all the conditions necessary for an experiment in the pathology of infection. As the epidemic spread, the permanent wards of the Smallpox Hospital were found to be insufficient to accommodate the increasing number of patients, and the Corporation decided to erect temporary pavilions within the Hospital grounds. On these 230 workmen comprising joiners, labourers, zinc workers, and engineers were employed. Of the total, 217 were successfully revaccinated immediately on commencing work, while thirteen either refused to be revaccinated or escaped revaccination through some misunderstanding or oversight. These men occupied the same class of houses, they lived upon similar food, they held the same social status, and not one belonged to the so-called "vagrant" class. They were all respectable men of the working class, and were exposed to precisely the same conditions while engaged in their work within the Hospital precincts. In fact, we have here all the conditions which would be considered essential in any experiment in biological science. Now see what happened. Of the 217 successfully revaccinated workmen *not one contracted Smallpox*, while of the thirteen who escaped revaccination *five contracted the disease and one died*.

From what has been said it is evident that whether revaccination was responsible for the immunity enjoyed by all but eight of the persons classified in the foregoing table, or not, the revaccinated persons did escape the disease, while half of those who were not revaccinated contracted it.

The persons referred to in the last few paragraphs were apparently completely protected by recent revaccination, or in other words, they apparently enjoyed for the time complete immunity. The question, however, arises whether this immunity is permanent or whether it diminishes by lapse of time and finally disappears. During the past ten or twelve years revaccination has been carried on in Glasgow to a considerable extent, and consequently we had in our midst prior to the commencement of the epidemic of last year a fair number of revaccinated persons. It was therefore of interest to observe what proportion of the patients admitted during the epidemic had been revaccinated. Out of the total number of admissions only eight were found to have been successfully revaccinated prior to their exposure to smallpox. The annexed table gives a list of these, and it will be noted that the person most recently revaccinated had submitted to the

operation four years previously. As there was reason to doubt the correctness of the date given by this patient, it is preceded in the table by a mark of interrogation.

TABLE SHOWING, IN CASES SUCCESSFULLY REVACCINATED BEFORE INFECTION, THE INFLUENCE OF REVACCINATION ON SEVERITY OF ATTACK.

Case.		Primary Vaccination.	Date of Revaccination.	Character of Attack.
No. 1,	Aged 25	1 mark—poor.	6 years ago.	Very sparse. ¹
„ 2,	„ 43	1 „ fair.	11 „	Sparse.
„ 3,	„ 44	1 „ poor.	21 „	Very sparse.
„ 4,	„ 37	1 „ poor.	27 „	Fairly abundant.
„ 5,	„ 48	1 „ poor.	28 „	Very sparse.
„ 6,	„ 43	3 „ poor.	31 „	Sparse.
„ 7,	„ 42	2 „ fair.	32 „	Very sparse.
„ 8,	„ 28	1 „ fair.	?4 „	Fairly abundant.

This list is a short one and the details require no comment, but the conclusion we are forced to from its study is that revaccination does not invariably afford a complete and permanent protection against smallpox. As already pointed out, the extent and permanence of the immunity will depend largely on the efficiency of the operation, and it is exceedingly difficult in view of this to estimate the degree of immunity enjoyed by any individual who has been revaccinated; and more especially is this the case where the revaccination has left little local scarring. How long the immunity afforded by thorough revaccination may last is a question very difficult of settlement. To judge by the list before us it seems that in one case where revaccination was undoubted the person contracted smallpox six years later, but in this case the scar pointed to a very inefficiently performed operation. Though little can be decided with regard to this point, it may be of interest to know that there are at present in the Smallpox Hospital nurses who apparently still enjoy complete immunity, whose last successful revaccination was performed ten or more years ago.

The conditions as regards susceptibility in revaccinated persons are probably somewhat similar to those in persons who have already had smallpox, and it is a matter of great interest to note that during the epidemic six persons at least were admitted with

¹ The patient was a housemaid in the service of Fever Hospital.

a second attack of this disease. The details of these are given in the following list :—

	Age.	Date of First Attack.	Character of Case.
No. 1.—50.		Precise date of first attack not known,	Fairly abundant.
„ 2.—50.	9 years ago,	- - - - -	Abundant, but ran rapid course.
„ 3.—32.	10 years ago,	- - - - -	Very sparse.
„ 4.—50.	40 years ago,	- - - - -	Very sparse.
„ 5.—50.	46 years ago,	- - - - -	Sparse.
„ 6.—54.	In early infancy,	- - - - -	Very sparse.

It may be stated that these patients, with the exception of the last, had been vaccinated in infancy, that the second on the list was an inmate of the Hospital nine years ago, when he passed through a very sharp attack of smallpox, and that in the first two cases the disease ran a course of considerable severity, in spite of the immunity which was presumably conferred by their former attack. None of these died. In addition to the cases enumerated in this list, several others stated they had passed through an attack of smallpox in earlier life, but as the historical evidence was not regarded as satisfactory, they have been omitted from our list.

It is almost certain that at the commencement of the outbreak of smallpox in 1900, there were more revaccinated individuals in our midst than there were persons who had already passed through an attack of smallpox, and yet we find that only eight of the former contracted the disease, while six incurred a second attack. Two of the cases passed through the second attack within ten years of the first, an experience comparable with that observed on studying the list of revaccinated persons, where, if we omit the last case in whom the date of revaccination is doubtful, we find that in the first two cases the period which elapsed between the date of revaccination and the attack of smallpox was in the one six, and in the other eleven years. In other points the two lists resemble each other pretty closely.

It would be unwise to dogmatise with regard to the relative immunity conferred respectively by revaccination and a former attack of smallpox, yet the experience of the outbreak would suggest that a revaccinated person is quite as safe from smallpox as one who has already passed through an attack of the disease.

During every epidemic of smallpox, more especially in the first few weeks of its course, a considerable number of more or less unprotected persons are brought into contact with others suffering from the disease, before the true nature of the illness is recog-

nised. The question therefore arises, what degree of protection is afforded to such persons by prompt vaccination and revaccination. It is obviously impossible to determine how many persons escaped smallpox entirely, as the result of vaccination or revaccination performed during the first few days after exposure to the infection, and it is impossible to decide by means of hospital statistics alone, what proportion of contacts escaped in whom the operation was performed during the later days of the incubation period. Yet some information may be derived from a study of the number of cases admitted to Hospital who were vaccinated or revaccinated on the different days included within the period of incubation, and of the severity of the attack. In the following table an attempt is made to give some information regarding this question. This table deals with cases of revaccination only.

TABLE SHOWING, IN CASES SUCCESSFULLY REVACCINATED AFTER INFECTION, THE INFLUENCE OF THE REVACCINATION ON SEVERITY OF ATTACK.

Number of Days before Sickening.	Day of Incubation Period.	Discrete.		Confluent.	
		Cases.	Deaths.	Cases.	Deaths.
13 days	—	1	—	—	—
12 „	—	1	—	—	—
11 „	1st	—	—	—	—
10 „	2nd	1	—	—	—
9 „	3rd	4	—	—	—
8 „	4th	13	—	—	—
7 „	5th	11	—	1	—
6 „	6th	6	—	1	—
5 „	7th	17	—	3	1
4 „	8th	20	—	2	—
3 „	9th	7	—	4	2
2 „	10th	3	—	2	—
1 „	11th	11	—	2	—
Day of sickening	12th	6	—	4	3
		101 ¹	—	19	6

When a person is in contact for several days with a case of smallpox, and subsequently contracts the disease, it is impossible to say at what particular moment he was attacked by the contagion, so that we are compelled, in discussing the question under consideration, to erect a standard, and though the period of incubation in smallpox is known to vary between eight and seventeen days, yet a period of incubation of twelve days is so common, that it seems permissible to select this term as our standard. In this table we have two cases vaccinated prior to the commencement of the twelve days' incubation period. These point, possibly, to thirteen or fourteen days' incubation, or they may be cases in

¹ Of these 83 were sparse and 18 abundant.

which the vaccinal reaction was delayed after revaccination. For our present purpose it will be best to set these aside, and consider only those embraced within a twelve days' period. A glance at the table will shew that, during the first three days of our selected incubation period, only five cases occurred among the many hundreds of contacts who were revaccinated, and it is consequently reasonable to suppose that many others would have contracted the disease had they not been protected by prompt revaccination.

During the epidemic a great majority of the patients admitted to Hospital were certified on or before the fifth day of illness, and more exceptionally at a later period. As the number of contacts was presumably in direct proportion to the number of cases, it follows that the great majority of these were exposed to the infection for a period of five days or less; so that there must have been more contacts revaccinated after a short than after a long exposure to the infection, or, in other words, during the earliest days of the incubation period. Yet we find that of those revaccinated during the first three days of the incubation period, only five contracted smallpox, and all were mild cases. Twenty-five cases were admitted who had been revaccinated during the fourth and fifth days of the incubation period, and all were mild except one case revaccinated on its fifth day of incubation, and there were no deaths. Twenty-seven cases admitted had been revaccinated on the sixth and seventh days after exposure, and of these four were confluent and one died. Thirty-three cases were admitted who had been revaccinated on the eighth or ninth day of the incubation period, and of these six were confluent and two died. Twenty-eight cases were admitted after revaccination had been performed on one of the last three days of the incubation period, and of these eight were confluent and three died.

It will be seen, therefore, that though the number of contacts presumably becomes less as the period of exposure lengthens, the number of persons admitted to Hospital from among these contacts becomes almost progressively greater, the drop during the last three days of the incubation period being no doubt due to the fact that only a very small number of cases of smallpox were admitted to Hospital after being kept at home for so long a time as ten to twelve days.

The conclusions to be drawn from a study of this table are—First, that thorough and successful revaccination, performed during the first three days of the incubation period, affords

an almost certain protection against the development of an incubating attack of smallpox ; second, that successful and thorough revaccination during the fourth and fifth days, while it may not absolutely protect against smallpox, yet renders the attack, in most cases, of a comparatively trivial character ; third, thorough and successful revaccination, performed during the sixth and seventh days of the incubation period, affords, if any, only a very modified protection, as out of twenty-seven cases four or 14·8 per cent. were confluent, while the case-mortality was one or 3·7 per cent ; fourth, thorough and successful revaccination, performed during the last five days of the incubation period, seems to afford no protection of any kind, for of 61 persons who contracted the disease after revaccination during this period, 14 or 23 per cent. developed it in a confluent form, while the case-mortality was 5 or 8·2 per cent.

We have now to deal with the question whether primary vaccination, performed during the period of incubation, exercises the same influence in preventing or modifying an incubating attack of smallpox, as does revaccination performed during the same period. In the following table twenty-three cases are grouped together in which primary vaccination was performed after exposure to infection. It may be observed that, in a few of the cases represented here, there was doubt as to whether vaccination had been performed in infancy or not ; but it has been thought legitimate to include these for our present purpose among those known to have been vaccinated for the first time during the period of incubation.

TABLE SHOWING, IN " UNVACCINATED " AND " DOUBTFUL " CASES VACCINATED AFTER INFECTION, THE INFLUENCE OF SUCH VACCINATION ON SEVERITY OF ATTACK.

Number of Days before Sickening.	Days of Incubation Period.				Discrete.		Confluent.	
					Cases.	Deaths.	Cases.	Deaths.
13 days	-	-	—	-	1	—	—	—
12 „	-	-	—	-	—	—	—	—
11 „	-	-	1st	-	—	—	—	—
10 „	-	-	2nd	-	—	—	—	—
9 „	-	-	3rd	-	3	—	1	1
8 „	-	-	4th	-	2	—	—	—
7 „	-	-	5th	-	2	—	1	—
6 „	-	-	6th	-	2	—	—	—
5 „	-	-	7th	-	1	1	2	1
4 „	-	-	8th	-	3	1	1	1
3 „	-	-	9th	-	—	—	—	—
2 „	-	-	10th	-	2	—	1	1
1 „	-	-	11th	-	—	—	1	1
Day of sickening,			12th	-	—	—	—	—
					16	2	7	5

For the purposes of comparison with our last table it will be advisable to omit from our discussion the first case, which was vaccinated thirteen days before the development of acute symptoms. Four cases, primarily vaccinated during the first three days of the incubation period, developed smallpox; three of the cases were mild, while one, a confluent case, died. Five cases, primarily vaccinated during the fourth and fifth days of the incubation period, developed smallpox; of these, four were mild and one confluent which recovered. Of five persons who developed smallpox after primary vaccination on the sixth and seventh days of the incubation period, two were confluent and two died. Of those vaccinated on the eighth and ninth days of the incubation period four developed the disease and two died. Of cases vaccinated during the last three days of the incubation period four developed the disease and two died. The numbers dealt with in this table are too small to warrant a deduction of any value, but, so far as they go, the conclusions are practically the same as indicated in the last table; that is to say, primary vaccination performed after the fifth day of the incubation period probably affords no protection against the development of the incubating disease.

CONCLUSIONS.—So far we have discussed in considerable detail, first, the case-mortality and relative severity of attack in vaccinated, unvaccinated, and doubtfully vaccinated subjects. Second, the relative degree of immunity indicated by vaccinal scars, varying in number, size and character. Third, the age-incidence in vaccinated, unvaccinated, and doubtfully vaccinated subjects. Fourth, the protective value of revaccination, and of a previous attack of smallpox; and fifth, the protective influence exercised by vaccination or revaccination performed at different dates after exposure to the infection. Though the conclusions led up to by the figures given in the different tables have been stated in the course of the discussion, it will be convenient to summarise them as follows:—

First.—There is a wide difference between the case-mortality among the vaccinated and unvaccinated, as in the former the death rate is 9·13 per cent., and in the latter 51·64 per cent. That is to say, the case-mortality among vaccinated persons is less than one-fifth of that among the unvaccinated.

The relative severity of attack as gauged by the amount of eruption and the period of detention in hospital, is much less

among the vaccinated than it is among the unvaccinated, as of the former 82·8 per cent. showed a discrete eruption, while of the latter only 43·4 per cent. did so, and the former were detained only half the time the latter spent in hospital.

Second.—The immunity enjoyed by vaccinated persons is apparently in direct proportion to the scar area and though less certainly, to the number of scars, while the immunity enjoyed by a person possessing foveated scars is greater than that enjoyed by one whose vaccinal scars are not foveated.

Third.—Among the vaccinated, children enjoy a peculiar immunity against smallpox, which can only be referred to the influence of primary vaccination. This immunity, however, becomes gradually weaker as age advances, till, at a varying age, depending apparently upon the efficiency of the primary vaccination, it is entirely lost, so that such persons have their susceptibility re established, and so become the victims of what is practically an unmodified disease.

Among the unvaccinated, a marked susceptibility to the disease is shown at all ages, the case mortality being high, and severity of attack very great in every age period.

Fourth.—Revaccination, if thoroughly performed, seems to restore the waning immunity conferred by primary vaccination, so that recent revaccination apparently confers complete immunity, the duration of which seems to be in direct proportion to the thoroughness of the operation.

A former attack of smallpox similarly confers immunity, the duration of which varies, like that resulting from revaccination.

Fifth.—The protection afforded by vaccination or revaccination after exposure to the infection varies with the time which elapses between exposure and the performance of the operation. Almost complete protection is afforded if the operation be performed during the first three days, while a modified protection results if it be performed between the third and sixth days after exposure.

